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(73) 実用新案権者 000140100  
株式会社荏原総合研究所  
神奈川県藤沢市本藤沢4丁目2番1号  
(72) 考案者 神沢 守仁  
神奈川県藤沢市本藤沢4丁目2番1号  
株式会社荏原総合研究所内  
(72) 考案者 鈴木 作  
神奈川県藤沢市本藤沢4丁目2番1号  
株式会社荏原総合研究所内  
(74) 代理人 弁理士 熊谷 隆(外1名)  
審査官 森 健一  
(56) 参考文献 実開 平1-167332 (JP, U)  
実開 平1-167333 (JP, U)

(54) 【考案の名称】 気体放電反応装置

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【(57) 【実用新案登録請求の範囲】

【請求項1】 厚さ0.5乃至2mmの板状の誘電体の片面に第1の電極を対向して配置し、該誘電体板の他面に第2の電極を密着させて配置し、前記第1の電極の前記誘電体板の対向面にはその頂部が線状の突起部を設け、突起部の頂部線状の厚さを0.5mm以下とし、且つ該頂部から前記誘電体板との間の間隙を組立て時に0.05乃至0.8mmとし、前記第1の電極と第2の電極との間に交番高電圧を印加し、前記第1の電極と前記誘電体板との間の空間内に放電を起こさせると共に、該空間に原料気体を前記第1の電極の突起部の長手方向に通過させることを特徴とする気体放電反応装置。

【考案の詳細な説明】

【0001】

【産業上の利用分野】 本考案は誘電体と該誘電体を挟ん

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で一対の電極とを具備する気体放電反応装置に関するものである。

【0002】

【從来技術】 従来、この種の気体放電反応装置としては、平板状の誘電体の裏面又はパイプ状誘電体の内面に一方の電極を密着させ、該誘電体の表面から1mm~数mm離れた平行位置に對電極を配置し、誘電体表面と對電極の等厚間隙中に無声放電を発生させ放電反応を起こさせるように構成した平行電極無声放電方式(以下、「平行電極型」と称する)が一般的である。

【0003】 また、誘電体の裏面又は内部に一方の電極を密着又は埋込、誘電体の表面に線状又は帯状の對電極を密着して配置し、誘電体表面に放電を起こせる沿面放電方式(以下、「沿面放電型」と称する)も実用化されている。

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【0004】一方誘電体表面側に配置される対電極は、その表面に土手状突起を設け、該突起の先端を誘電体の表面に密着するように配置し、該突起間の凹みと誘電体表面との間に形成されるトンネル状空間を原料及び反応生成物の流路兼放電空間とする方式（以下、「突起接触型」という）も提案されている（特願昭61-286306号公報参照）。この方式は前記平行電極型と沿面放電型の複合方式というべきもので放電電力密度が大幅に高くなる。従って、これを例えればオゾンの生成に用いた場合、オゾン濃度及び単位放電面当りのオゾン生成量を高めることができると他、種々の効力が生じるとされている。

#### 【0005】

【考案が解決しようとする課題】しかしながら、上記平行電極型と沿面放電型との複合方式の突起接触型は下記のような問題点があった。

【0006】①土手状突起先端近傍の放電密度が極めて高く該先端部及び誘電体の損耗が起こり易い。

【0007】②土手状突起先端と誘電体面とが少なくとも運転中は接触し、且つ接触圧力を一般的に脆弱な誘電体を破損しない範囲に留まるよう組み立てることが難しい。これは主に放電反応装置において、電極及び誘電体の逆転中の温度上昇やガス圧や冷却水圧によって電極及び誘電体が変形することによる。

【0008】③空気を原料とするオゾン生成において、 $N_{Ox}$ の生成が増え、オゾン濃度は平行電極型よりも低くなる。

【0009】本考案は上述の点に鑑みてなされたもので、上記①乃至③の問題点を除去或いは軽減してより改良された複合式の気体放電反応装置を提供することを目的とする。

#### 【0010】

【課題を解決するための手段】上記課題を解決するため本考案は気体放電反応装置を図1に示すように、厚さ0.5乃至2mmの板状の誘電体板1の片面に第1の電極2を対向して配置し、該誘電体板1の他面に第2の電極3を密着させて配置し、第1の電極2の誘電体板1との対向面にはその頂部が線状の突起部4を設け、突起部4の頂部線状の厚さt（図2）を0.5mm以下とし、且つ該頂部から誘電体板との間の間隙δを組立て時に0.05乃至0.8mmとし、第1の電極2と第2の電極3との間に交番高電圧を印加し、第1の電極2と誘電体板3との間の空間内に放電を起こさせると共に、該空間に原料気体を第1の電極2の突起部4の長手方向（図1において、紙面直角方向）に通過させる構成とした。

#### 【0011】

【作用】気体放電反応装置を上記のように構成することにより、突起部4の先端と誘電体板1とを0.05mm～0.8mm離しているので両者が接触している前記突起接触型より、突起部4の先端近傍の放電密度は緩和される

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から、該電極先端部及び対向する誘電体板の損耗を低減できる。

【0012】また、突起部4の先端と誘電体板の間も気流が流れているので、温度上昇も軽減され、一部の気流が高密度空間に長時間滞留することも軽減され、これらも電極及び誘電体板の損耗低減及びせっかく生成した生成物を分解してしまうことの軽減に寄与する。

【0013】一方、第1の電極2は先端の鋭い突起部4が設けてあるから電荷が集中し、該突起部4の先端と誘電体板1との間隔δは0.05～0.8と小さくしているので、放電開始電圧は最小約1kvと小さく、一旦放電が開始すると僅かの電位差の増加によって放電は突起部と突起部との間の領域にまで容易に広がり、低い印加電圧でも放電領域全体の平均放電密度をでも大きくすることができる。

【0014】放電開始電圧が低いことも誘電体板1や電極2の突起部先端の損耗低減に寄与するし、生成物の汚染低減にも役立つ。また、平均放電密度が高いことは、例えばオゾン生成において、放電電極の面積当りの生成量や濃度を高くすることに寄与する。更に、印加電圧を低く抑えられることは電源の製作、価格において有利となる。

【0015】また、突起部4の先端と誘電体板1は接触していないので、使用中の温度変化や気体及び冷却水の圧力等によって、誘電体板1と突起先端間に過大な圧力がかかることもなく、脆弱な誘電体板1を損壊する危険性もなくなる。

【0016】従って、突起部4の先端と誘電体板1との距離は使用中に互いに接触しないようにする必要があり、一方小型の放電反応装置において、突起部4の高さ、誘電体板1の厚さの精度はそれぞれ容易に1/100～2/100mm、2/100～3/100mmにできるので、間隔δを最低5/100mm以上とすることが、現実的である。一方、間隔δを大きくすると、放電開始電圧、最大印加電圧共に大きくなる必要が生じ、0.8mmを越えると、反応特性が平行電極型と類似していく。つまり本考案の特徴が薄れる。

【0017】また、突起部4の先端を誘電体板から離すことによって、空気を原料とするオゾン生成において、 $N_{Ox}$ の生成が抑制される。このメカニズムはあきらかでないが、突起部4の先端を誘電体板から離すことによって、放電空間5の体積とそれを形成する壁面積（第1の電極2と誘電体1の放電空間側表面積の和）の比が大きくなることによるものと考えられる。

【0018】なお、気流を突起部4の先端と誘電体板1との間隙を横断する。つまり気流を突起部4の長手方向と直角に流すことも考えられるが、特に間隔δが小さい場合に気流の圧損が大きくなる。また、突起部4の先端の包絡面と誘電体板1の表面とのわずかな不平行による気流の偏流のため放電反応性能が顕著に低下する。

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気流は突起部4の長手方向に平行とすることが必要である。

【0019】

【実施例】以下、本考案の実施例を図面に基づいて説明する。図1は本考案の気体放電反応装置の構造を示す横断面図である。図1において、1は板状の誘電体板であり、該誘電体板1の片面に第1の電極2を対向して配置し、他面に第2の電極3を密着させて配置している。前記誘電体板1と第2の電極3は水冷ケース6の上部に嵌合している。前記第1の電極2はパッキン8を介在して水冷ケース6の上部に配置され、該第1の電極2は押え枠9により放電間隔δを所望の値にするように固定されている。

【0020】誘電体板1は厚さ0.65mmの96%の酸化アルミニウム( $\text{Al}_2\text{O}_3$ )材からなる誘電体である。第1の電極2は図2に示すように、断面山形でその頂部が線状になっている突起部4を有しており、該突起4の高さは1.5mm、ピッチは3mm、突起部4の頂部線状の厚さ $t=0.05\text{ mm}$ とし、放電空間5側の表面に厚さ約10μmの陽極酸化処理膜を被覆したアルミニウム材からなる。

【0021】第2の電極3は誘電体板1の表面に形成した約10μmのAg-Pd系のメタライズ層である。第1の電極2の突起部4の先端と誘電体板1との間隔δは0.25±0.05mmとしている。第1の電極2には突起部の反対側に冷却用フィン2-1が設けられている。水冷ケース6は合成樹脂製で、その内部は複数のリブ6-1(図では3枚)で仕切られ水冷ジャケット7が形成されている。前記第2の電極3の裏面はケース6の周囲上端と該リブ6-1で支えられている。

【0022】パッキン8はメチルシリコンゴム製で、緩衝と共にシール作用を果たしている。押え枠9も合成樹脂製である。なお、図1において、10は接地側リード線であり、11は高圧側リード線である。また、図示しない2個のノズルを同図紙面の手前側及び奥側に設け、それぞれ放電空間5への原料気体の入口、生成物の放電空間5からの出口となっている。また、原料気体は第1の電極2の突起の長手方向に平行に流れようになっていいる。

【0023】上記構成の気体放電反応装置において、放電空間に工業用酸素又は乾燥した空気を供給し、リード線10, 11間に6.5kVの高周波電圧を印加して、第1の電極2と誘電体板1の間の放電空間5に放電を起こし、オゾン発生装置とした場合の性能を測定した場合の結果は下記のようであった。なお、この場合、水冷ジャケット7には給水して第2の電極3を冷却する。

【0024】放電開始電圧は1.2kV~1.3kVであり、3.5kV印加した時の放電電力密度は14kW/m<sup>2</sup>となり、従来の実用化されている気体放電反応装置より大幅に高いが運転・停止を含む数ヶ月余の耐久試

験において、第2の電極2の突起4の先端及び誘電体板1ともなんらの損傷も認められなかった。

【0025】また、オゾン生成性能としては、酸素原料で最大オゾン濃度が180mg/Nl(リットル)以上、生成量が酸素原料で2kg/m<sup>2</sup>·h、空気原料で0.96kg/m<sup>2</sup>·hと前記平行電極型より大幅に大きくなる。つまり、第1の電極2の突起部4の先端と誘電体板3を離した本実施例において、前記沿面放電型や突起接触型よりも優れた結果を得た。空気原料においても、前記突起接触型では、放電電力を約5kWh/m<sup>3</sup>以上かけるとNO<sub>x</sub>の生成が増しオゾン、濃度、生成量ともかえって減少するが、本実施例では約8kWh/m<sup>3</sup>までNO<sub>x</sub>の生成が顕著にならず、結果として最大オゾン濃度24mg/Nl(リットル)が得られた。

【0026】なお、上記構成の気体放電反応装置において、誘電体板の厚さは、強度、製作のし易さ、高密度放電に耐え得る放熱性、更に所望の放電密度を得るために必要な印加電圧を低くするために0.5~2mmが適当である。また、頂部が線状の突起部4の断面形状は先端の厚さ $t$ が0.5mm以下とできるだけとがったものであれば特に限定されず、図2、図3及び図4に示すように、横断面が三角形或いは円弧の組合せ状でもよく、更には突起が連続的に配置されていても、突起と突起との間に誘電体1の面と平行な部分が存在する不連続の配置でもよい。但し、突起4の個々の形状及びピッチは均一であることが望まれる。

【0027】なお、本考案の気体放電反応装置は、誘電体板、先端が線状である突起を持つ第1の電極及び第2の電極をそれぞれ円筒形にした管型の放電反応装置にすることもできる。

【0028】

【考案の効果】以上説明したように本考案の気体放電反応装置によれば、放電による誘電体板や電極の損耗或いは破壊を低減或いは防止しながら高密度放電が実現できるから、これをオゾン生成に使用した場合、放電面積当たりのオゾン生成量及び濃度を高くでき、小型化ひいては低価格で且つ長寿命のオゾン発生装置となるという優れた効果が得られる。また、NO<sub>x</sub>の発生も抑制できる。

【図面の簡単な説明】

【図1】本考案の気体放電反応装置の構造を示す横断面図である。

【図2】本考案の気体放電反応装置の第1の電極の一形状例を示す斜視図である。

【図3】本考案の気体放電反応装置の第1の電極の他の形状例を示す斜視図である。

【図4】本考案の気体放電反応装置の第1の電極の他の形状例を示す斜視図である。

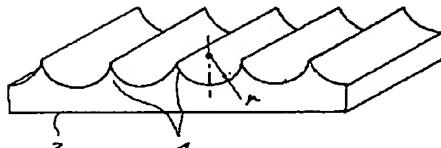
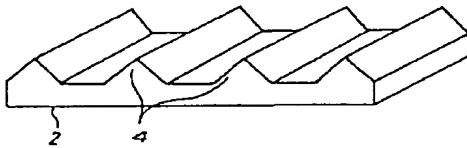
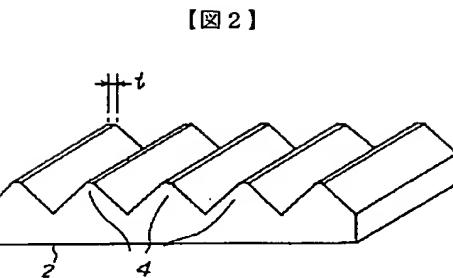
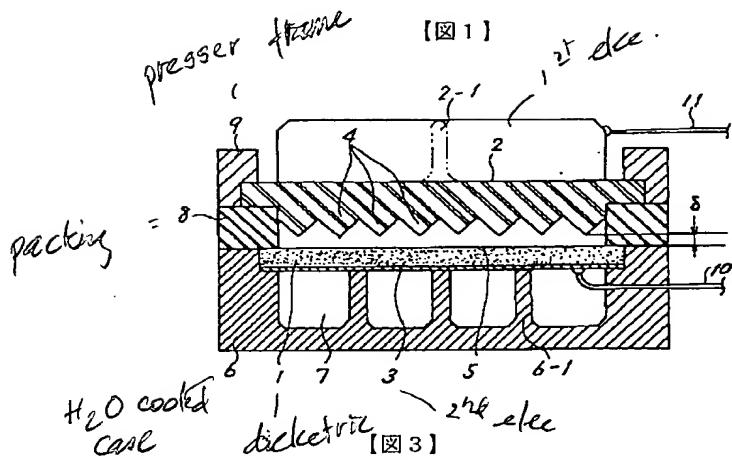
【符号の説明】

1	誘電体板
2	第1の電極

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- 3 第2の電極  
4 突起部  
5 放電空間  
6 水冷ケース  
7 水冷ジャケット

- 8 パッキン  
9 押え枠  
10 リード線  
11 リード線



Japanese Utility Model Registration No. 2540627/1997

Registration Date: April 18, 1997

Application No. 35287/1991

Application Date: April 18, 1991

Laid-Open No. 122641/1992

Laid-Open Date: November 4, 1992

Devisers: KANZAWA Morihito et al.

Right's Assignee: Ebara Research Co. Ltd

Title of the Device: GASEOUS DISCHARGE REACTION

#### APPARATUS

##### [Claim]

1. A gaseous discharge reaction apparatus comprising:

disposing a first electrode opposite to one side of a plate-like dielectric plate having a thickness of 0.5 to 2 mm;

placing a second electrode in intimate contact with the other side of the dielectric plate;

providing projecting parts having a linear top part on the surface of said first electrode, the surface facing to said dielectric plate;

setting a thickness of a linear portion of the top part of the projecting parts 0.5 mm or under; and setting a distance between the top part and said

dielectric plate 0.05 to 0.8 mm when assembled, wherein an alternate high voltage is applied between said first electrode and said second electrode to generate a discharge in a space between said first electrode and said dielectric plate and a source gas is passed through the space in a longitudinal direction of the projecting parts of said first electrode.

[Detailed Description of the Device]

[0001]

[Field of Industrial Application]

The present device relates to a gaseous discharge reaction apparatus comprising a dielectric and a pair of electrodes sandwiching the dielectric.

[0002]

[Prior Art]

Conventionally, as this kind of gaseous discharge reaction apparatus, a parallel electrode silent discharge system (hereafter, it is referred as a "parallel electrode type") is typical in which one electrode is brought into intimate contact with the backside of a plate-like dielectric or the inner surface of a pipe-like dielectric, a counter electrode is placed at a parallel position remote from the

surface of the dielectric by 1 mm to several mm, a silent discharge is generated in a gap of equal thickness between the dielectric surface and the counter electrode and a discharge reaction is created.

[0003]

Additionally, a creeping discharge system (hereafter, it is referred as a "creeping discharge type") is also in practical use in which one electrode is brought into intimate contact with the backside of the dielectric or buried therein, a linear or belt-like counter electrode is placed in intimate contact with the surface of the dielectric and a discharge is generated on the dielectric surface.

[0004]

On the other hand, a system (hereafter, it is referred as a "projection contact type") is also proposed in which bank-like projections are provided on the surface of the counter electrode that is disposed on the dielectric surface side, the tip ends of the projections are placed so as to come into intimate contact with the surface of the dielectric and a tunnel-like space formed between a recessed part that is between the projections and the dielectric surface is adapted to be a passage for a source material and a reaction product as well as a discharge

space (see, Japanese Patent Application No. 286306/1986). This system should be called a combined system of the parallel electrode type with the creeping discharge type as set forth; a discharge power density is substantially increased. Therefore, when it is used for generating an ozone, for example, an ozone concentration and an amount of the ozone generated per unit discharge area can be increased and a variety of effects will occur.

[0005]

[Problems that the Device is to Solve]

However, the projection contact type of the combined system of the parallel electrode type with the creeping discharge type set forth had following problems.

[0006]

(1) A discharge density near the tip ends of the bank-like projections is extremely high and wear in the tip end parts thereof and the dielectric tends to occur.

[0007]

(2) It is difficult to assemble the tip ends of the bank-like projections and the dielectric surface so that the tip ends of the bank-like projections come into contact with the dielectric surface at least

during operation and a contact pressure is contained in a range that does not break the dielectric that is generally fragile. This is mainly because the electrodes and the dielectric become deformed due to a temperature rise in the electrodes and the dielectric during operation, a gas pressure or a cooling water pressure in the discharge reaction apparatus.

[0008]

(3) In ozone production using air as a source material, the generation of a Nox is increased while an ozone concentration is rather decreased.

[0009]

The device was devised in the light of the points described above and the purpose thereof is to provide a combined type gaseous discharge reaction apparatus eliminating or reducing the aforesaid problems (1) to (3) to be more improved.

[0010]

[Means for Solving the Problems]

In order to solve the problems set forth, the device configured a gaseous discharge reaction apparatus as shown in Fig. 1, the apparatus comprising:

disposing a first electrode 2 opposite to one side of a plate-like dielectric plate 1 having a

thickness of 0.5 to 2 mm;

placing a second electrode 3 in intimate contact with the other side of the dielectric plate 1;

providing projecting parts 4 having a linear top part on the surface of the first electrode 2, the surface facing to the dielectric plate 1;

setting a thickness  $t$  (Fig. 2) of a linear portion of the top part of the projecting parts 4 0.5 mm or under; and

setting a distance  $\delta$  between the top part and the dielectric plate 0.05 to 0.8 mm when assembled, wherein an alternate high voltage is applied between the first electrode 2 and the second electrode 3 to generate a discharge in a space between the first electrode 2 and the dielectric plate 3 and a source gas is passed through the space in the longitudinal direction of the projecting parts 4 of the first electrode 2 (the direction orthogonal to the paper surface in Fig. 1).

[0011]

[Operation]

By configuring the gaseous discharge reaction apparatus as set forth, the tip ends of the projecting part 4 are separated from the dielectric plate 1 by 0.05 mm to 0.8 mm and thus the discharge density near

the tip ends of the projecting parts 4 is more relaxed than the aforesaid projection contact type where both the tip ends of the projecting part 4 and the dielectric plate 1 are in contact with each other. Therefore, wear in the tip end parts of the electrode and the dielectric plate facing thereto can be reduced.

[0012]

Additionally, since an air current flows between the tip ends of the projecting parts 4 and the dielectric plate, a temperature rise is reduced and a part of the air current residing in a high density space for a long time is also decreased. These also contribute to a reduction in wear in the electrode and the dielectric plate and a reduction in a generated product long waited being decomposed.

[0013]

Meanwhile, the first electrode 2 is provided with the projecting parts 4 having an acute tip end and thus an electric charge is centered. The distance  $\delta$  between the tip end of the projecting part 4 and the dielectric plate 1 is set small as 0.05 to 0.8 and therefore the minimum discharge starting voltage is as small as approximately 1 kv. Once a discharge begins, the discharge easily spreads to the area between the

projecting parts by a slight increase in a potential difference. Even a low applied voltage can increase a mean discharge density in the entire discharge area.

[0014]

A low discharge starting voltage also contributes to the reduction in wear in the dielectric plate 1 or the tip ends of the projecting parts 4 of the first electrode 2 and is useful for a decrease in contaminating the generated product as well.

Additionally, a high mean discharge density contributes to an increase in an amount generated per area of the discharge electrode or an increased concentration in ozone production, for example.

Furthermore, allowing an applied voltage to be held low is advantageous in power source production and costs.

[0015]

Moreover, because the tip ends of the projecting parts 4 are not in contact with the dielectric plate 1, an excessive pressure is not applied between the dielectric plate 1 and the tip ends of the projecting parts due to a temperature variation in use or the pressure of a gas, a cooling water and the like. The risk of breaking the fragile dielectric plate 1 is also eliminated.

[0016]

Therefore, the distance between the tip ends of the projecting parts 4 and the dielectric plate 1 needs to be set so as not to contact each other in use. On one hand, in a small-sized discharge reaction apparatus, the accuracy of the height of the projecting part 4 and the thickness of the dielectric plate 1 can easily be set 1/100 to 2/100 mm and 2/100 to 3/100 mm, respectively and thus setting the distance  $\delta$  at least 5/100 mm or greater is practical. On the other hand, when the distance  $\delta$  is set greater, both the discharge starting voltage and the maximum applied voltage need to be set greater. When it exceeds 0.8 mm, reaction properties become similar to the parallel electrode type. That is, the characteristic of the invention is faded.

[0017]

Additionally, by separating the tip ends of the projecting parts 4 from the dielectric plate, the generation of the Nox is suppressed in ozone production using air as a source material. This mechanism is not clear. However, it is considered that separating the tip ends of the projecting parts 4 from the dielectric plate causes a ratio of the volume of a discharge space 5 to a wall area forming thereof

(the sum of the surface area on the discharge space side of the first electrode 2 and the dielectric 1) to become greater.

[0018]

Furthermore, the air current is made to cross between the tip ends of the projecting parts 4 and the dielectric plate 1. That is, passing the air current in the direction orthogonal to the longitudinal direction of the projecting parts 4 is also considered but pressure losses of the air current become greater particularly when the distance  $\delta$  is small. Moreover, the drift of the air current due to the envelope of the tip ends of the projecting parts 4 not being parallel slightly to the surface of the dielectric plate 1 degrades discharge reaction performance remarkably. Therefore, the air current needs to be set parallel to the longitudinal direction of the projecting parts 4.

[0019]

[Example]

Hereafter, an example of the device will be described according to drawings. Fig. 1 depicts a cross-sectional view showing the structure of the gaseous discharge reaction apparatus of the device.

In Fig. 1, 1 is a plate-like dielectric. A first

electrode 2 is disposed opposite to one side of the dielectric plate 1 and a second electrode 3 is placed in intimate contact with the other side of the dielectric plate 1. The above-mentioned dielectric plate 1 and the second electrode 3 are fit in the upper part of a water cooled case 6. The first electrode 2 set forth is disposed on the upper part of the water cooled case 6 through a packing 8. The first electrode 2 is fixed by a presser frame 9 so as to set a discharge distance  $\delta$  to a desired value.

[0020]

The dielectric plate 1 is a dielectric comprising 96 % of an aluminium oxide ( $Al_2O_3$ ) material having a thickness of 0.65 mm. As shown in Fig. 2, the first electrode 2 has projecting parts 4 of angular cross section having a linear top part. The projecting part 4 has a height of 1.5 mm, a pitch of 3 mm and a thickness  $t$  of the linear portion of the top part being set 0.05 mm. The first electrode 2 comprises an aluminium material having a surface on the discharge space 5 side coated with an anodized film having a thickness of approximately 10  $\mu m$ .

[0021]

The second electrode 3 is a metallized layer of an Ag-Pd system formed on the surface of the

dielectric plate 1 and having a thickness of approximately 10  $\mu\text{m}$ . The distance  $\delta$  between the tip end of the projecting part 4 of the first electrode 2 and the dielectric plate 1 is set  $0.25 \pm 0.05 \text{ mm}$ . A cooling fin 2-1 is disposed on the opposite side of the projecting part of the first electrode 2. The water cooled case 6 is made of a synthesis resin. The inside thereof is partitioned by a plurality of ribs 6-1 (three ribs in the drawing) and formed with water cooled jackets 7. The backside of the aforesaid second electrode 3 is supported by the peripheral upper end of the case 6 and the ribs 6-1.

[0022]

The packing 8 is made of a methyl silicon rubber, serving a sealing effect as well as a buffer. The presser frame 9 is also made of a synthetic resin. Additionally, in Fig. 1, 10 is a ground side lead wire and 11 is a high-tension side lead wire. Furthermore, two nozzles, not shown, are disposed on the near side and the back side of the paper surface of the drawing, being adapted to be an inlet of the source gas to the discharge space 5 and an outlet of the product from the discharge space 5, respectively. Moreover, the source gas is set to flow in the direction parallel to the longitudinal direction of the projections of the

first electrode 2.

[0023]

In the gaseous discharge reaction apparatus configured as set forth, the following results were shown when performance was measured in the case that the apparatus was adapted to be an ozone generator in which an oxygen for industrial use or a dry air was supplied for the discharge space, a high frequency voltage of 6.5 kHz was applied between the lead wires 10 and 11 and a discharge was generated in the discharge space 5 between the first electrode 2 and the dielectric plate 1. Additionally, in this case, the water cooled jackets 7 are supplied with water to cool the second electrode 3.

[0024]

The discharge starting voltage was 1.2 kV to 1.3 kV and the discharge power density became 14 kW/m<sub>2</sub> when a voltage of 3.5 kV was applied, substantially higher than an orthodox commercialized gaseous discharge reaction apparatus. However, in endurance tests for several months including operation and shutdown, no damage was observed in both the tip ends of the projecting parts 4 of the second electrode 2 and the dielectric plate 1.

[0025]

Additionally, as ozone generating performance, the maximum ozone concentration is 180 mg/Nl (liter) or greater by an oxygen source, the amount generated is 2 kg/m<sup>2</sup>.h by the oxygen source and 0.96 kg/m<sup>2</sup>.h by an air source, becoming substantially greater than the aforesaid parallel electrode type. That is, the example in which the tip ends of the projecting parts 4 of the first electrode 2 are separated from the dielectric plate 1 attained results more superior than the creeping discharge type or the projection contact type as set forth. In the air source, when a discharge power of approximately 5 kWh/m<sup>3</sup> or more is applied, the generation of the Nox is increased and the ozone, its concentration and the amount generated are rather decreased in the aforesaid projection contact type. However, in the example, the generation of the Nox was not observed noticeably up to approximately 8 kWh/m<sup>3</sup>. Consequently, the maximum ozone concentration of 24 mg/Nl (liter) was obtained.

[0026]

Furthermore, in the gaseous discharge reaction apparatus configured as set forth, the thickness of the dielectric plate is suitably set 0.5 to 2 mm for reducing an applied voltage necessary to obtain strength, easiness for production, radiation

characteristics capable of resisting the high density discharge and further a desired discharge density. Moreover, the cross-sectional geometry of the projecting parts 4 having a linear top part is not limited in particular as long as the thickness  $t$  of the tip end is pointed as possible as 0.5 mm or under. As shown in Figs. 2, 3 and 4, the cross section may be triangular or combination of circular arcs and further projections may be disposed continuously or may be arranged discontinuously sandwiching a portion parallel to the surface of the dielectric 1 therebetween. However, the respective geometries and pitches of the projections 4 are desired to be uniform.

[0027]

Besides, the gaseous discharge reaction apparatus of the device may be adapted to be a tubular discharge reaction apparatus in which each of the dielectric plate, the first electrode having the projections with a linear top and the second electrode is formed in a cylindrical shape.

[0028]

[Effect of the Device]

As described above, according to the gaseous discharge reaction apparatus of the device, a high

density discharge can be realized as the wear or breakage of the dielectric plate or electrodes due to a discharge is reduced or prevented. Thus, when it is used for generating the ozone, the amount of the ozone generated per discharge area and its concentration can be increased and excellent results can be obtained for making an ozone generator of small size, low costs and long lifetime. Besides, the generation of the Nox can be suppressed as well.

[Brief Description of the Drawings]

Fig. 1 depicts a cross-sectional view showing the structure of the gaseous discharge reaction apparatus of the device;

Fig. 2 depicts a perspective view showing one geometric example of the first electrode of the gaseous discharge reaction apparatus of the device;

Fig. 3 depicts a perspective view showing another geometric example of the first electrode of the gaseous discharge reaction apparatus of the device; and

Fig. 4 depicts a perspective view showing another geometric example of the first electrode of the gaseous discharge reaction apparatus of the device.

[Description of the Reference and Signs]

- 1 dielectric plate
- 2 first electrode
- 3 second electrode
- 4 projecting part
- 5 discharge space
- 6 water cooled case
- 7 water cooled jacket
- 8 packing
- 9 presser frame
- 10 lead wire
- 11 lead wire